

Claims

- [c1] 1.A method of forming a transistor on a semiconductor substrate comprising:
forming at least one gate structure on the semiconductor substrate;
performing a surface cleaning process, the surface cleaning process comprising:
utilizing a chemical oxidation method for forming a first oxide layer on a surface of the semiconductor substrate not covered with the gate structure; and
removing the first oxide layer; and
utilizing a selective epitaxial growth method for forming a first epitaxial layer on the surface of the semiconductor substrate.
- [c2] 2.The method of claim 1 further comprising performing the surface cleaning process repeatedly for removing a first thickness of the semiconductor substrate.
- [c3] 3.The method of claim 2 wherein the chemical oxidation method utilizes an oxidant acid to form the first oxide layer.
- [c4] 4.The method of claim 3 wherein the surface cleaning

process utilizes a diluted hydrofluoric acid to remove the first oxide layer.

- [c5] 5.The method of claim 4 wherein the oxidant acid is a mixture comprising sulfuric acid (H_2SO_4), hydrogen peroxide (H_2O_2), and deionized water.
- [c6] 6.The method of claim 5 wherein a volume ratio of sulfuric acid to hydrogen peroxide is approximately 4 to 1, and a temperature of the oxidant acid is about 125°C.
- [c7] 7.The method of claim 4 wherein the oxidant acid is a mixture comprising sulfuric acid (H_2SO_4), ozone (O_3), and deionized water, and a temperature of the oxidant acid is about 35°C.
- [c8] 8.The method of claim 2 wherein a thickness of the first oxide layer approximately ranges from 15 angstroms (Å) to 30angstroms, and the first thickness approximately ranges from 10 angstroms to 50angstroms.
- [c9] 9.The method of claim 2 wherein forming the gate structure comprises the following steps:
 - forming a gate oxide layer on a portion of the semiconductor substrate;
 - forming a gate electrode on the gate oxide layer;
 - forming a liner oxide layer on the semiconductor substrate to cover the gate electrode;

forming a dielectric layer on the liner oxide layer; and performing an etching-back process on the liner oxide layer and the dielectric layer to form a spacer on side-walls of the gate electrode; wherein the gate structure comprises the gate oxide layer, the gate electrode, and the spacer.

[c10] 10.The method of claim 9 wherein the chemical oxidation process further comprises forming a second oxide layer on a surface of the gate electrode.

[c11] 11.The method of claim 10 wherein the second oxide layer and the first oxide layer are removed simultaneously.

[c12] 12.The method of claim 11 wherein the selective epitaxial growth method further comprises forming a second epitaxial layer on the surface of the gate electrode.

[c13] 13.The method of claim 9 further comprising performing an ion-implantation process for forming a source electrode in the semiconductor substrate adjacent to one side of the gate structure and forming a drain electrode in the semiconductor substrate adjacent to another side of the gate structure.

[c14] 14.The method of claim 13 wherein the ion-implantation process is performed before the surface cleaning process

is performed.

- [c15] 15.The method of claim 13 wherein the ion-implantation process is performed after the first epitaxial layer is formed.
- [c16] 16.The method of claim 12 further comprising forming silicide layers on both the first epitaxial layer and the second epitaxial layer.
- [c17] 17.The method of claim 12 wherein the semiconductor substrate is a silicon substrate, and the first epitaxial layer and the second epitaxial layer are both silicon epitaxial layers.
- [c18] 18.A selective epitaxial growth process comprising:
providing a substrate, a surface of the substrate comprising a first region, a second region, and a mask layer covering the second region;
performing a surface cleaning process, the surface cleaning process comprising:
forming an oxide layer on the first region of the substrate; and
removing the oxide layer; and
forming an epitaxial layer on the first region of the substrate.
- [c19] 19.The process of claim 18 further comprising perform-

ing the surface cleaning process repeatedly for removing a portion of the substrate containing impurities.

[c20] 20.The process of claim 19 wherein the surface cleaning process utilizes an oxidant acid to oxidize a surface of the first region to form the oxide layer.

[c21] 21.The process of claim 20 wherein the oxidant acid is a mixture comprising sulfuric acid (H_2SO_4), hydrogen peroxide (H_2O_2), and deionized water.

[c22] 22.The process of claim 21 wherein a volume ratio of sulfuric acid to hydrogen peroxide is approximately 4 to 1, and a temperature of the oxidant acid is about 125°C.

[c23] 23.The process of claim 20 wherein the oxidant acid is a mixture comprising sulfuric acid (H_2SO_4), ozone (O_3), and deionized water, and a temperature of the oxidant acid is about 35°C.

[c24] 24.The process of claim 19 wherein the surface cleaning process utilizes a diluted hydrofluoric acid to remove the oxide layer.

[c25] 25.The process of claim 19 wherein the substrate is a silicon substrate, and the epitaxial layer comprises a silicon epitaxial layer, a silicon germanium (SiGe) epitaxial layer, or a SiGeC epitaxial layer.

[c26] 26. The process of claim 18 wherein the mask layer is a gate structure that comprises a gate oxide layer formed on a portion of the second region of the substrate, a gate electrode formed on the gate oxide layer, and a spacer formed on sidewalls of the gate electrode.